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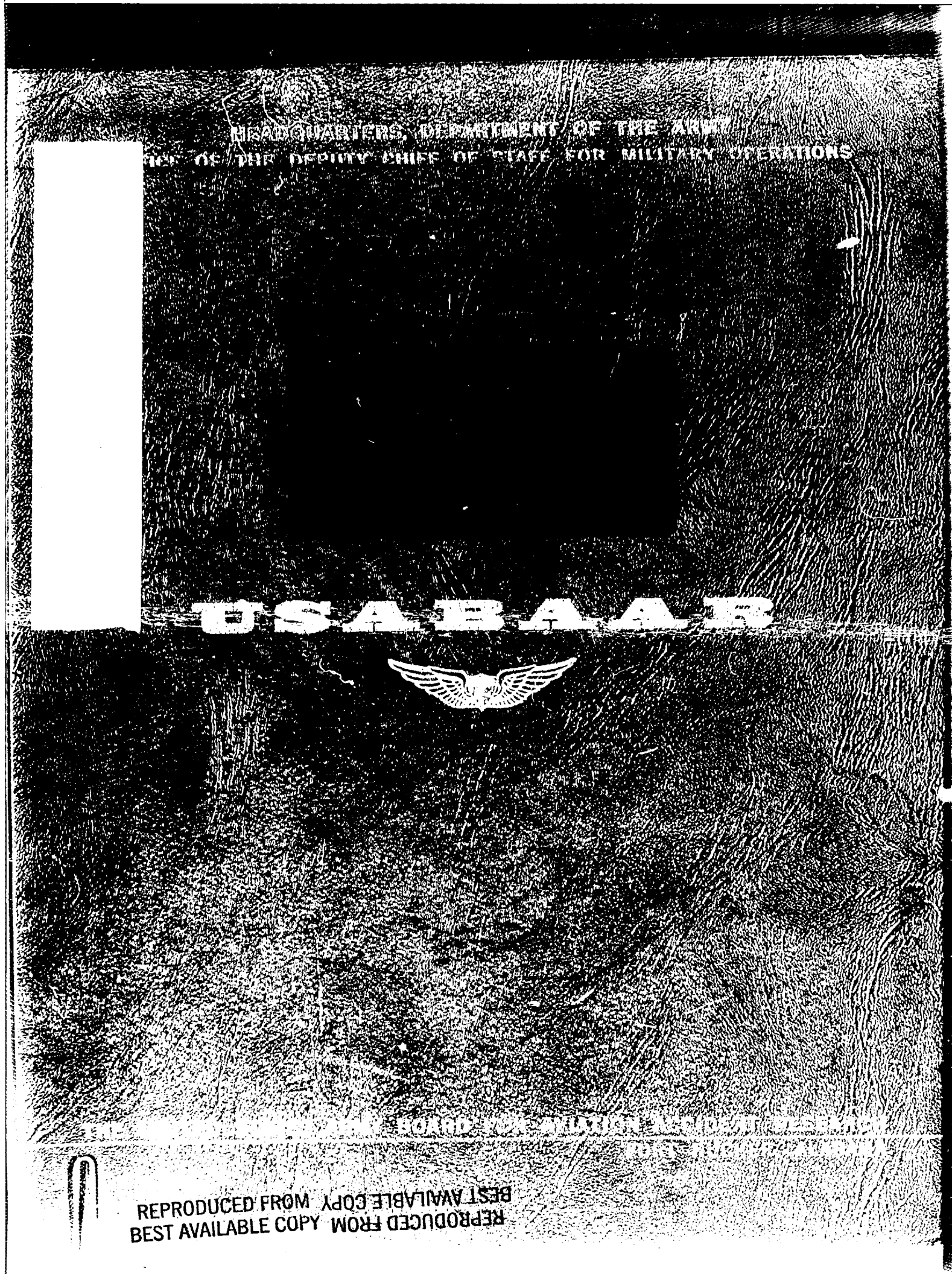


ARMY AVIATION

HELMET EXPERIENCE

ANALYSIS AND RESEARCH DIVISION

HUMAN FACTORS SECTION

REPORT NO. HF 4-61

UNITED STATES ARMY BOARD FOR

AVIATION ACCIDENT RESEARCH

Fort Rucker, Alabama

ABSTRACT

The purpose of this research was to determine the effectiveness of hard shell helmets for preventing loss of life and injuries during Army aircraft accidents and to summarize user comments on helmets in current use.

The wearing of hard shell helmets was credited with prevention of head injuries to 265 occupants of Army aircraft during the period studied. Factors of convenience and comfort, particularly heat retaining qualities, constitute major objections to wearing the APH-5 helmet.

SUMMARY

During the period 1 July 1957-31 December 1960, 1220 major Army aircraft accidents occurred. Two thousand eight hundred thirteen available records indicate 991 occupants were not wearing helmets at the time of the accident and 202 (20%) received head injuries classified as major, critical, or fatal. Fifty eight suffered fatal head injuries, accounting for over one third of all fatalities which occurred during this period.

Conversely, 265 occupants were "saved" from head injury because protective helmets were worn. The majority of these "saves" (200) occurred after October 1959 (issue date of APH-5 helmet to Army aviators). Rotary wing occupants outnumbered fixed wing occupants by 3 to 1 in the number of head injuries prevented, though rotary wing aircraft were involved in only 3% more accidents. This difference may be due in part to the definition of a major aircraft accident, based on the number of man hours required for repair. Consideration in comparison must be given the crash durability of the two types of aircraft.

A questionnaire survey of flight surgeons and aviators revealed the following factors concerning the APH-5 helmet:

1. Problems of procurement still persist.

2. Spare parts are not available.

3. The practice of issuing the helmet as personal equipment for permanent retention is widespread.

4. Some reluctance to wearing helmets still exists. Comfort and convenience factors are the major objections. Heat retention qualities are of great concern to users.

5. Retention of the helmet during crash sequence is a problem, particularly in rotary wing aircraft accidents.

INTRODUCTION

This report considers Army aviation accident experience with protective helmets during the period 1 July 1957-31 December 1960. Information was taken from accident reports on file with the U. S. Army Board for Aviation Accident Research. More recent experience with the APH-5 helmet was obtained by a questionnaire survey of Army flight surgeons and aviators.

Experience reflected in Army aircraft accident reports after October 1959 (issue date of APH-5 helmet) indicates helmets are preventing and reducing the severity of head injuries. However, problems of color, retention, heat, proper fitting, optical characteristics of the sun visor, and non-availability of spare parts still exist.

The APH-5 helmet is an interim model in the development of an improved type of protective head gear for Army aviation personnel. The Quartermaster Corps is currently engaged in design and development of a helmet that will provide crash protection, ballistic protection, and improved noise attenuation.

Although this study emphasizes the helmet, it must be recalled that any protection offered by the APH-5 or later models is only one factor to be considered in the effort to reduce injuries and fatalities in Army aircraft accidents. The great majority of these accidents are theoretically survivable,* but lives continue to be lost and needless injuries sustained due to deficiencies in seat tie-down, lack of shoulder harness, potentially lethal cockpit configurations, inadequate rescue/signal devices, improper flight gear or clothing, and the reluctance of Army aviators to make maximum use of the safety devices provided them.

*An accident is defined survivable if the crash forces imposed upon the occupants are within the limits of human tolerance (50 to 150g transverse to the spine) and any portion of the inhabitable area of the aircraft remains reasonably intact; i. e., is not collapsed sufficiently to impinge upon, or crush vital areas of a person seated in a normal position.

METHOD

This report is based on analyses of two primary data sources:

1. Army aviation accident experience, before and after introduction of the APH-5 helmet, taken from the accident report files of USABAAR. One thousand two hundred twenty major accidents which occurred during the period 1 July 1957-31 December 1960 were analyzed.

2. A questionnaire survey of Army flight surgeons and aviators was conducted. Questionnaires were mailed to 50 Army flight surgeons during December 1960. Thirty one flight surgeons responded. Eight flight surgeons in geographically diverse locations were asked to distribute questionnaires to 20 aviators under their care. One hundred thirty three responses were received from this source.

CONCLUSIONS

The frequency of head injuries produced in Army aircraft accidents has been reduced substantially since APH-5 helmets were issued in October 1959.

Initial reluctance to wear this helmet does not appear to remain a widespread problem, although it is evident in some individual cases. Factors of convenience and comfort are the most serious objections to wearing the helmet. The heat retaining quality is the complaint most often voiced.

The problem of helmet retention is evidenced by 21 instances during 1960, in which the helmet was dislodged at some time in the accident sequence.

A comparison of fixed and rotary wing accidents reveals that occupants of rotary wing aircraft are subject to a considerably greater chance of incurring head injuries. One hundred eighty four occupants of rotary wing aircraft, versus 80 occupants of fixed wing aircraft were "saved" from head injury due to wearing the APH-5 helmet.

Some evidence exists which indicates that flight surgeons are not assuming responsibility, or not given opportunity, to properly fit aviators with the helmet.

Limitation of sizes, plus those available with sizing pads, appears to be insufficient. Flight surgeons have been unable to fit some aviators. Consequently, many still fly without the helmet.

As late as February 1961, problems of supply still persisted and made it impossible for aviation units to equip all aviators with helmets.

RECOMMENDATIONS

Factors of convenience and comfort, particularly heat and fit, be given careful consideration in the design and development of future protective helmets.

Practice of issuing protective helmets as personal equipment for permanent retention be adopted Army-wide. Recommend this practice begin with the first flights of student pilots.

Future procurement provide spare parts required in repair and replacement of the helmet assembly.

DISCUSSION

A. AVIATION ACCIDENT EXPERIENCE

1. CRASH PROTECTION

Records show the head is a frequent site of injury in both automobile and aircraft accidents. Aviation Crash Injury Research reported injuries sustained by 800 survivors of lightplane accidents(1). In this study, the body was divided into 18 areas for comparison and showed 88% of the survivors sustained head injuries.

The United States Army Board for Aviation Accident Research analyzed L-19 accidents occurring during the period July 1957-October 1959, in which injuries sustained were classified as major, critical, or fatal(2). A review was made to determine frequency of head injury among 58 occupants. It showed 91% of front seat occupants and 65% of rear seat occupants sustained head injuries.

USABAAR report, HF 3-61, to be published, will outline "Injury Patterns in Army Aircraft Accidents" and indicate frequency of injuries to various body areas.

Table 1
U. S. Army Aircraft Accident Experience
of Occupants Not Wearing Helmets
July 1957-December 1960

	Rotary Wing	Fixed Wing	Total
No Head Injuries	398	391	789
Head Injuries (Greater than Minor)	80	64	144
Fatal Head Injuries	19	39	58
	497	494	991

Table 1 reflects injury experience of 991 occupants involved in major accidents during the period 1 July 1957-31 December 1960. None wore protective helmets. They were involved in 649 rotary wing and 571 fixed wing accidents.

Approximately 20% of the occupants suffered head injuries classified as major, critical or fatal. Fifty eight received fatal head injuries. This accounts for 36% of the 161 aircraft accident fatalities which occurred during this period.

Thirty fatalities due to head injuries were either pilots or co-pilots. The remainder were listed as passengers, crew chiefs, etc. Fixed wing accidents accounted for twenty pilot fatalities, or twice the number resulting from rotary wing accidents.

Since mid-October 1959, fifteen fatalities due to head injuries have occurred. Only two of these were crew members. This finding may be an omen of the fatality picture to come when more and more passengers (troops) are carried under tactical operational conditions.

Table 1 also shows 789 (79%) of the occupants escaped head injury. This finding reflects the nature of Army aircraft accidents, proving the majority of occupants will escape head injuries, whether or not a helmet is worn. This experience may produce the reluctance of older aviators, particularly fixed wing aviators, to wear helmets. The Quartermaster Research and Engineering Center conducted a study in 1957 (3) to determine the opinions of Army aviators stationed in Korea. This study showed that 4% of those surveyed felt protective helmets were not necessary for Army aviators. It also indicated that 85% of the aviators surveyed preferred crash protection in a helmet, rather than ballistic protection. Conversely, 11% indicated preference for ballistic protection.

Reluctance to wear a helmet appeared great enough at the time the APH-5 was issued to justify further inquiry. More than 100 key Army aviation personnel were queried by USABAAR concerning the need for a regulation to govern wearing of the APH-5 helmet. Eighty replies were received, indicating that these aviators were also concerned about the problem. Sixty one percent favored such a regulation. One half indicated the helmet should be worn in all Army aircraft except command types (e.g., L-23). Twenty four percent indicated the helmet should be worn in all types of Army aircraft.

The regulation governing wearing of APH-5 helmets now reads: "Helmets, APH-5, when available, will be worn during combat, tactical training, test flights, or similar flights that involve unusual hazards and other times as prescribed by unit commanders." When this regulation was published, the Army aircraft accident experience during the period July 1957-April 1960 was reviewed to determine the number of accidents in which the helmet would have been worn as required by the regulation. The findings of this review were:

a. Helmets would not have been required in 897 of 989 (89%) accidents.

b. Helmets would not have been required in 115 of 133 (87%) aircraft accidents in which injuries were produced.

c. Helmets would not have been required in 53 of 60 (88%) accidents which involved fatal injuries.(4)

These are alarming statistics and should be so regarded, particularly by aviators reluctant to wear helmets and by unit commanders unwilling to define, direct, and enforce the "other times" when helmets will be worn. Table 2 shows the helmet is being worn and performing its designed task. Aviators responsible for the helmet's excellent record, and for minimizing resistance to the wearing of helmets, were those whose attitude is reflected in the following statements:

a. "The wearing of the helmet has been mandatory under threat of punishment by the C. O.; so we have no problem with failure to use helmets."(5)

b. "Having been aboard in one rotary wing accident, when my head resembled a pineapple after regaining consciousness, I need no encouragement for wearing a protective helmet in any type of aircraft."(6)

c. "I consider the shoulder harness, parachute, and now the helmet, the cheapest form of life insurance available to the Army aviator."(7)

Table 2
U. S. Army Aviation
Accident Experience of Occupants Wearing a Helmet
July 1957-December 1960

	R/W	F/W	TOTAL
Helmet prevented head injury	158	79	237
Helmet prevented more serious head injury	26	2	28
Helmet failed to prevent fatal head injury	3	0	3
Helmet structure failed	3	2	5
Dislodged during impact	21	1	22

Table 2 reflects crash experiences of occupants of fixed and rotary wing Army aircraft who wore helmets at the time of impact. Investigation reports of these accidents indicate that the helmets either absorbed or reduced injury producing forces sufficiently to prevent head injury or more serious head injury to 265 of 268 occupants. Though rotary wing aircraft were involved in only 3% more accidents than were fixed wing aircraft, the number of "saves" in rotary wing aircraft more than doubled the number of "saves" in fixed wing aircraft (184 R/W vs 81 F/W). The number of "saves" demonstrates the vital need for this type of protection.

The experience of a pilot and crew chief involved in an HU-1 accident indicates the effectiveness of helmets in rotary wing aircraft accidents.

> "... The pilot strapped to his seat, passed forward and through the right corner post of the pilot's compartment. Marks on the corner post and pilot's APH-5 helmet indicated his head made contact with the right corner post. He received only minor head injuries. The investigators unanimously agreed the APH-5 helmet saved the pilot from probable fatal head injuries. The crew chief was also thrown from the aircraft. There is good reason to believe that he passed through the opening made by the pilot."[8] (NOTE: The crew chief escaped with minor lacerations)

Accident experience (Table 2) proves that chances of escaping head injuries are extremely good when helmets are worn. The problem of providing this protection is that of insuring that occupants wear helmets throughout crash sequences. The solution to this problem appears to lie in control of its three primary factors: 1-availability of helmets, 2-reluctance to wear helmets, and 3-retention of the helmet on the head throughout the crash sequence. Each of these factors are considered in this report.

During calendar year 1960, (Figure 1) helmets prevented head injuries to 185 occupants involved in major Army aircraft accidents. This reflects well on the success of the helmet program and the effectiveness of the APH-5 helmet.

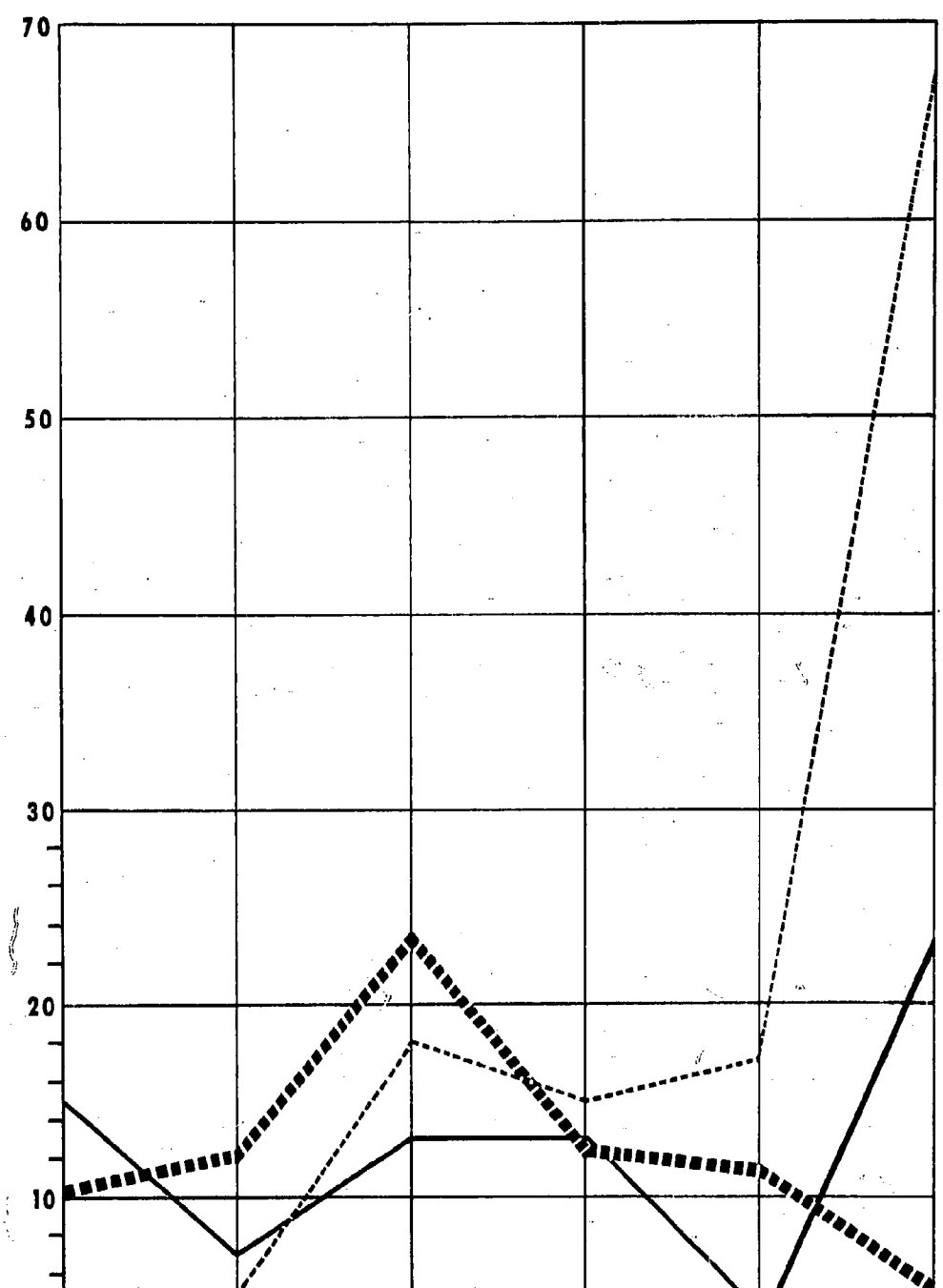

70
60
50
40
30
20
10
JULY '57
JULY '60
F/W HEAD INJURIES-no helmet provided
R/W HEAD INJURIES-no helmet provided
F/W HELMET USED-prevented injury
R/W HELMET USED-prevented injury

FIGURE 1

The greater number of "saves" in rotary wing aircraft does not in itself justify a greater need for head protection in helicopters. The structural design of helicopters, the forward and rather exposed location of occupants, and the tendency of helicopters to move laterally and roll over during crash sequences are felt to be basic reasons for some of this difference. Light observation reconnaissance helicopters (examples: H-13 and H-23) best illustrate this fact. In this type of aircraft, the occupants are seated forward, inclosed in a plastic bubble which offers little protection and usually fractures at impact. Also, there is negligible aircraft structure inclosing the occupants to absorb energy at impact. H-23 and H-13 helicopters comprise the greatest number of aircraft in the rotary wing inventory. They accomplish more than half of the total hours flown by Army rotary wing aircraft, account for nearly 50% of rotary wing accidents, and are the only rotary wing aircraft not fully equipped with shoulder harnesses. The lack of shoulder harness is a major factor in the number of head injuries sustained in these aircraft. Its significance is revealed in a study of fatal Army helicopter accidents.(9) This study showed:

> ". . . Head injuries and burns accounted for most of the deaths in survivable accidents."
>
> "Approximately three-fourths (77%) of survivable accidents involved reconnaissance helicopters."
>
> "More than half (59%) of reconnaissance helicopter accidents were survivable. These accounted for 75% of the fatalities in survivable accidents."

No fixed wing aircraft accidents have been reported to USABAAR in which helmets failed to prevent fatal head injuries. Only three such accidents involving rotary wing aircraft have been reported. There is reason to doubt in one of these cases, considering the nature of crash forces, that fatal head injuries could have been prevented. However, it was apparent the helmet prevented instant death in this case and increased chances for survival. During this accident,(10) the pilot's seat failed, moved slightly forward and violently to the left. The pilot's head struck the left windshield frame resulting in transmission of forces through the helmet. Examination of the helmet revealed a fracture across the left brace of the eye shield housing and cracking of the polyester resin lining corresponding to the location of the exterior fracture. No other damage was visible. The cause of death, which occurred 17 hours after the accident, was reported to be intracranial hematoma, right fronto-temporal.

Before the issue of APH-5 helmets, some Army aviators were wearing "borrowed" Navy M-4 and Air Force P-3 helmets, and other types when available. In 17 cases of the accident experiences studied, head injuries were either prevented or reduced because of these "borrowed" helmets. A flight surgeon, describing one of these accidents, stated:

"Following this sequence of events (crash of an Army helicopter), the occupants ricocheted around the cockpit, resulting in their heads striking the rear wall, upper horizontal window frames and the rotor brake handle. Thanks to the wearing of locally purchased and unauthorized crash helmets, as well as the harness and safety belts, no injuries were received by the occupants. The helmets effectively absorbed all forces, in addition to preventing the rotor brake handle from entering the pilot's brain."(11)

2. FAILURE OF APH-5 HELMET ASSEMBLY

The study of accident experience revealed only eight* failures of the APH-5 shell assembly. Impact forces were estimated to be well beyond the design limits of the helmet in four of these cases. The shells were crushed. The other four failures included two reported cases of transverse cracks, one crack about the ear piece, and a crack at the lower mounting point of the eye shield housing. In each of these cases, injuries were incurred.

Numerous failures of other components of the helmet assembly have been reported. One of these involved the sun visor. The flight surgeon reporting this accident said:

"The protective helmet, APH-5, functioned well except that the visor, which was in the 'down' position, was broken. The broken edges were very sharp, almost razor edged, and inflicted a laceration over the right eye."(8)

Describing how a crack about the ear piece occurred, another flight surgeon said:

"...with the chin strap drawn tight, the pilot was thrown forward and to the right with his helmet contacting the heavy vertical member of the windshield frame. The pilot sustained a moderately severe contusion above the right ear. Investigation of the helmet revealed softening of the fiberglass shell about the right ear and wrinkling of the sharp edge of the energy absorbent liner above the right ear."(12)

*Three of these failures occurred after December 1960

This flight surgeon recommended beveling of the sharp edges of the energy absorbent liner, or extending a thin layer of this material down between the ear phones and shell.

3. HELMET RETENTION

The Army's early and relatively short experience with aviator protective helmets can be regarded as excellent (see Table 2). Navy and Air Force accident experience indicates that helmet retention continues to be a problem for which no good or final answer has yet been found. Concerning this problem, the Naval Air Materiel Center wrote:

"The difficulty is that there is no satisfactory standard test for helmet retention because we cannot simulate the movement of the human head and neck during deceleration. We have put APH-5's without chin or nape straps on dummies, strapped the dummies in seats and, using the horizontal accelerator, subjected them to 40G deceleration. The helmet stayed on. Using a hinged plate to support a dummy head, which will allow it to fall forward on deceleration, produces inconsistant results."(18)

Since 1957, Army aircraft accident experience reveals 22 cases in which occupants lost their helmets during crash sequence. Eighteen of these occurred during 1960. With one exception, all were APH-5 helmets. Most of these cases involved occupants of rotary wing aircraft. It is believed that the whipping action, coupled with lateral motion, which seems to be characteristic of rotary wing aircraft accidents, accounts for the greatest number of helmet losses. It is known that the helmet has a tendency to rotate about the head during any quick motion of the head. Multi-directional forces of helicopter accidents amplify this tendency. If the helmet is not properly fitted, with nape strap tight and chin strap snugly secured, it is likely to be dislodged during this type of accident.

Loose nape straps, unfastened or ill-fitting chin straps were cited as causes in half of the APH-5 helmet losses which occurred during 1960. Materiel failure, a broken chin strap at the rivet attachment on the left, was cited only once.

Factors of convenience and comfort should not be overlooked as true reasons why the helmet is often worn with the chin strap loose or unfastened.

Responses from flight surgeons and aviators to a questionnaire survey made this point quite clear. Several recommended and/or

installed foam rubber or chamois on the strap. Likewise, a number of recommendations were made for an improved fastener which would attach quickly and with greater ease. Recommendations were also made for an adjustable nape strap.

Detailed information describing the manner in which helmets become dislodged is not generally available. Wearers are usually unable to supply this information. Intensive interrogation is normally to no avail. One aviator, describing helmet loss at impact, made the following typical comment:

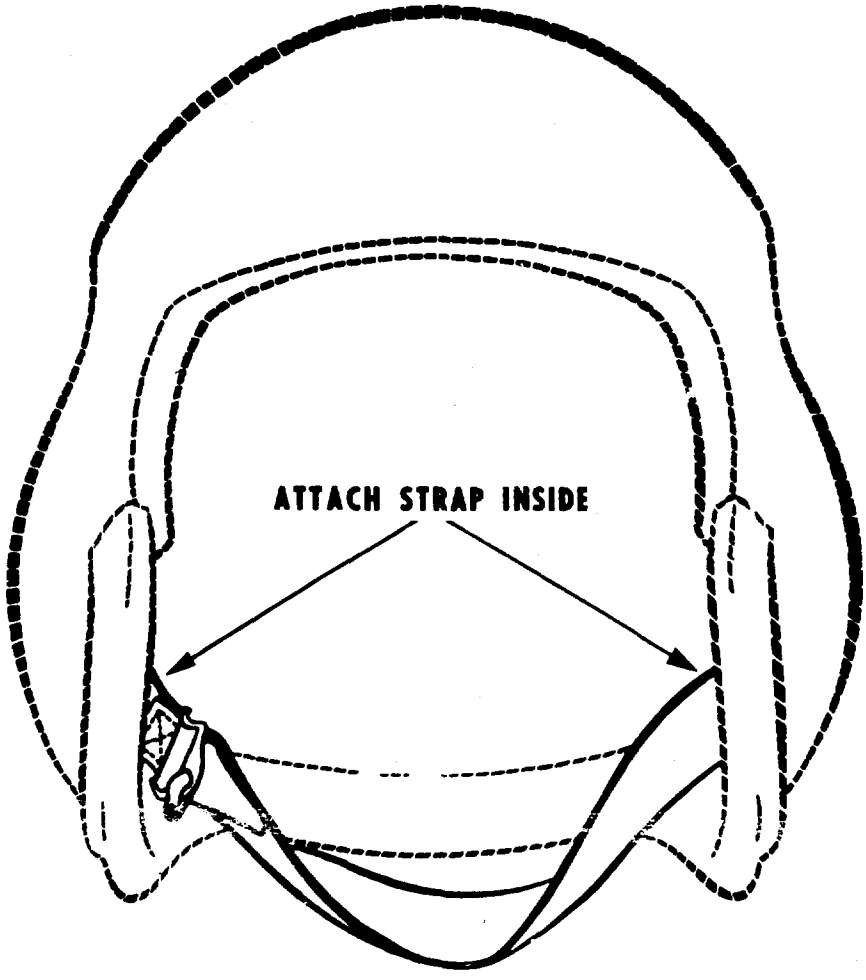
"I do not remember the specific position of the helmet chin strap, but almost invaribly I tighten it to a loose contact with the chin. The sun shield was in the down position. I recall a sensation of lightness following initial ground contact and suspect the helmet was thrown off at that time."(14)

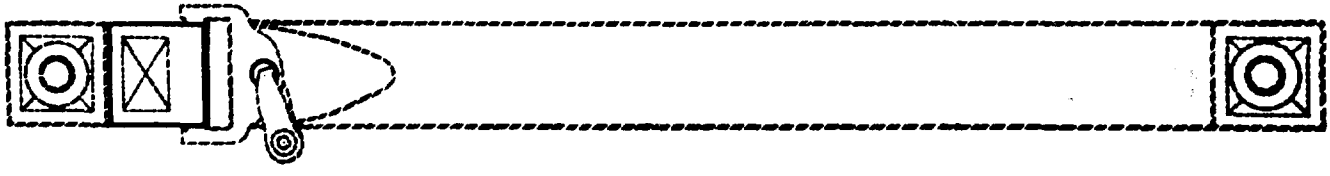
(NOTE: The helmet was later found lying in the path of the crash and behind the aircraft's final resting point.)

The helmet retention problem in Army aviation was brought vividly to light by an H-37 accident.(15) This accident resulted in extreme impact forces and post crash fire. The five occupants suffered fatal injuries. Only one occupant retained his helmet. Two occupants lost their helmets at impact. The death of one of these was attributed to skull fracture and intracranial injuries. Investigators suspected that the other two occupants also lost their helmets at impact. However, head injuries were not reported as the cause of death in either of these cases.

An Army flight surgeon,(16) working on the problem of helmet retention, has devised a modification (Figure 2). This consists of increasing the chin strap length at the buckle end to approximately three inches, and locating strap attaching points inside the helmet. This modification results in the helmet strap contacting a greater surface of jaw and chin, improving retainability and comfort when the helmet is worn snugly, as it should be. Other suggestions for solving this problem were installation of a cup type chin strap, or the installation of two straps. In the latter modification, the second strap would also terminate at the chin cup, but it would be installed further back on the helmet.

FIGURE 2





INCREASE LENGTH 3'' HERE

The problem of the APH-5 helmet rolling forward off the head at impact has not been solved. Installation of the nape strap is not the final solution. Experience shows the nape strap, which forms a chord across the helmet below the occipital prominence and has a dimension smaller than the occipital prominence, does not always prevent the helmet from rolling forward and off.

The best test of retention found thus far is easy for the wearer to perform. This test is conducted by donning the helmet, fastening the chin strap tightly and trying with both hands to take it off either forward or backward.

4. HELMET COMFORT

Many Army aviators have volunteered complaints about the comfort of APH-5 helmets (see Table 5). Though none of these objections have resulted in or contributed to accidents, some have been cited as potential cause factors. Flight surgeons have reported aviators experiencing near accidents due to perspiration running into their eyes. Helicopter aviators, operating where the weather is hot and/or humid, have reported a necessity to land and wipe perspiration from their faces and helmet interiors.

The flight surgeon at the Army Primary Helicopter School, Camp Wolters, Texas, wrote:

"The aviators are complaining that the helmet is too hot. I know this is not a new problem, but it is the first time we have had serious repercussions with it here. I think the problem is made more severe in that the bubble of the H-23 acts as a magnifying glass. This, combined with the hot Texas sun, results in an uncomfortable situation. Actually, some of the aviators have experienced some potentially serious symptoms. Among these are lightheadedness, blurring of vision, nausea, and a feeling of impending syncope. One check pilot complained of perspiration rolling down into his eyes and blinding him. This occurred at the bottom of an autorotation at the time pitch was pulled. (Note: Collective pitch is pulled at the termination of an autorotative landing to slow the descent.) The check pilot stated that it was fortunate the student pulled pitch properly, because at that particular time he (the check pilot) was completely incapacitated from the perspiration in his eyes." (17)

Another medical officer reported:

"Many aviators are complaining that with these new helmets (APH-5) they are having trouble with negative pressure forming between

the ears and earphones. This probably results from heat expanding the air and then the sweat sealing off the rims of the earphones, not allowing air to return on cooling, thereby causing the ear drum to be 'sucked out.' I believe a cloth covering over the earphones might relieve this problem."

Some aviators complain that the helmet's weight of approximately 3.5 pounds is fatiguing and often causes neck muscles to become sore and tender. Others say head mobility is hampered by the helmet's bulkiness and weight distribution. This interferes with side and rearward visibn.

5. HELMET COLOR AND FINISH

Comments on the heat problem invariably question the O. D. color of the APH-5 helmet. One study[19] utilized fitted O. D. and white painted helmets on brass heads, instrumented to measure the solar heat load on the helmets. Results of this study were reported as follows:

"Painting the helmet white instead of O. D. will decrease the physical solar load significantly and should be done if there are no other overriding reasons to the contrary. However, the physiological gain to be expected from this is insignificant compared with the total head load the inactive wearer must handle when wearing the APH-5 helmet in a warm environment and/or in the bright sun.

"Since these results indicate that color difference in the helmets does not contribute a significant physiological heat load, statements by users concerning differences in heat effects must be due primarily to other helmet variable or psychological factors. When a pilot compares the heated surfaces of white and O. D. helmets by use of his hand a difference in external surface temperature is noted. This may lead him to generalize that the heat differential is present in the internal area of the helmet."

This study also noted that no empirical data are available to indicate whether psycho-physiological factors involved in wearing the helmet have a significant effect on performance.

Camouflage is the reported reason for painting the APH-5 helmet an olive drab color with a walnut flour finish. This reason is often subject to argument. Strong points are offered to effect a change. One flight surgeon had this to say:

"The arguments for the O. D. color are very easily refuted. You just cannot camouflage an H-21 by painting the pilot's hat brown. The helmet should really be painted light in color for aid in rescue, be it over water or land."(20)

Others argue this same point, using increased visibility rather than heat absorption as a prime requirement. One said:

"It is my belief that had the pilots been wearing crash helmets painted with high visibility flourescent (paint) they could have been detected more easily. Should not the same safety reasons which require high visibility markings on Army aircraft also apply to the APH-5 helmet? Why camouflage them with olive drab? In case of a crash, not only would they furnish protection, but could also aid the rescue party in locating the crash scene. All flying of this unit is either over water or wooded areas. High visibility painted helmets would greatly aid in the location of personnel in the event of ditching in water or crashing in a wooded area."(21)

Another said: "A man with a spray gun can cover day-glo paint (on the helmet) with olive drab in five minutes if a war occurs."(22)

Studies of helmet visibility have shown the white helmet is far more visible than any other color, including the best flourescent orange and red paints available. The white helmet is visible from 1200 feet, but is not visible beyond that distance from the air.

The British reported in R. A. F. studies that a rough finish, such as the APH-5's walnut flour, a grainy finish, will increase the hazard of injuries. Their helmets have a smooth exterior finish which enables the helmet to deflect from, or slide over an object or surface when struck. A smooth finish is an essential feature in providing protection against impact which causes high rotational acceleration to the head. This type of force is considered by them to be the most frequent cause of concussion.

The APH-5 helmet finish is criticized by many for its poor quality to resist chipping and scratching, which detracts from its appearance and is a deterrent to those reluctant to wear it.

6. NOISE ATTENUATION

The APH-5 helmet, equipped with the ear cup type headset, is effective in attenuating high noise levels of Army aircraft, particularly those produced by helicopters. Threshold shift evaluations have found

the helmet assembly to be very effective at the lower frequencies. This effectiveness is significantly greater at the higher frequencies.

Many aviators, particularly those not accustomed to the helmet, do not agree that noise reduction is in the best interest of safety. These feel the helmet greatly reduces their ability to detect odd or unusual noises in flight. These noises are often the first indication of trouble and the need for emergency procedures.

7. EYESHIELD AND VISORS

The APH-5 eyeshield and interchangeable tinted visors have been the source of critical comments by flight surgeons and aviators. Aviators, though concerned about vision deficiencies, particularly distortion, more frequently express their operational experience with the visor. Some of these remarks are:

"Quite hot when down."

"Doesn't fit about the nose snugly."

"Visor scratches too easily."

"Visor does not operate easily."

"Taped lower edge of visor blocks view of some instruments."

"Find the visor to be very tiring on the eyes when used for extended periods. Its qualities in haze are limited. I use sun glasses on all flights and find it more comfortable and less tiring to my eyes."

Flight surgeons are more prone to comment on the optical properties of the visor. The following state, taken from an accident report, reflects this concern:

"This pilot and many others have expressed dislike of the tinted visor. It produces a subjective discomfort in some, a feeling of not being able to see quite as well with it as without it. Some feel that the visor makes things look closer than they really are, and have found themselves hovering higher than normal when wearing the visor."(23)

8. SIZING PADS

Tendency of sizing pads (liners) to fall out of place is reported as a source of irritation to APH-5 helmet users. Apparently, this is

due to the properties of the adhesive. Irritation stems not only from the need to replace the pads each time and the likelihood of losing the pads, but from inability to regain proper feel and fit.

Recommendations have been received, regarding the perspiration problem, to fabricate the front pad from a material with higher absorptive qualities.

9. EARPHONE AND CUSHION

The earphones and cushions like the eyeshield, chin strap, color, pads and poor ventilating qualities have attributed to the overall dissatisfaction expressed by the aviators about the APH-5 helmet. A sampling of the critical statements of these components are:

"Cushions deteriorate much too rapidly."

"Excessive perspiration caused by the cushions."

"Difficult to remove and to clean."

"Too tight, cause severe pain."

"Replace the string tie back method of the headset."

The deterioration and excessive perspiration problem has been reduced by installing a nylon netting over the cushions.

B. ANALYSIS OF FLIGHT SURGEON-AVIATOR QUESTIONNAIRE SURVEY

This portion of the report is comprised of the responses to questionnaries submitted to Army flight surgeons and aviators. The questionnaire sought to gather their experience with the APH-5 helmet after its first full year in the field.

The questionnaire, distributed during December 1960, required both objective and subjective answers. A letter accompanying the questionnaire stated its purpose, the intended use of responses and offered anonymity to respondees.

At the time the questionnaires were distributed, the Surgeon General listed 39 geographical locations at which Army flight surgeons were practicing aviation medicine. Fifty flight surgeons at these locations were sent questionnaires. Thirty one responded. In addition, flight surgeons in eight geographical diverse locations were asked to distribute questionnaires to 20 aviators under their care. One hundred thirty three responses were received from this source.

Following are the questions asked, tabulated responses and a brief analysis of findings.

> "1. Do aviators of your unit use only the Army issued APH-5 helmet? If not, give other models in use and approximate number."

Twenty one affirmative replies were noted. This item reflects the use and acceptance of the present helmet by flight personnel. Ten aviation units indicate Air Force helmets are still in use. Superior comfort plus deficient APH-5 supply were cited as factors for their use. A relatively small number of Air Force helmets is in use and reportedly does not exceed two at any station. Apparently, the Army helmet distribution has reached a majority of active flight personnel.

> "2. Are helmets issued for permanent retention? (i. e., will the helmet accompany the individual on PCS?) If not, give reason."

The great majority (87%) indicated the helmet was issued for permanent retention. This is considered excellent since many problems would be created if this practice is not adopted. Helmets short in supply was cited by one location reporting negatively to this question and local policy preventing crew chiefs from retaining their helmets was given in the remaining cases.

"3. Were any problems encountered in the issue of the APH-5 helmet after a supply of them had been received at your post? Is distribution delayed now for any reason? If yes, explain."

This two part question created considerable comment. Eight of the 29 responding reported problems of distribution. These were:

a. Helmets issued to the post rather than to the aviation unit. One unit then moved out taking more than half of the helmets.

b. Helmets were in supply, but no money was available to "pay" for them, so the issue was delayed. (Reported three times).

c. Initial supply level was inadequate. (Reported twice).

d. A discrepancy between the size of helmets and pads and head sizes.

Part two of the question was devised for the purpose of determining whether these same problems persisted. Seven reporting locations remarked distribution is still delayed and remains as a problem. The reasons given in these cases were:

a. Local QM supply does not maintain a level, so each individual request must be processed to CONUS, resulting in a long delay.

b. Initial supply inadequate, which still leaves a shortage.

c. Lack of and unavailability of spare parts.

d. Non-availability of helmets in the theater. Arriving aviators from flight school at Rucker were without helmets. No authority to stock helmets.

e. Awaiting permission of higher authority to distribute some 150 APH-5 helmets presently in stock at the post warehouse.

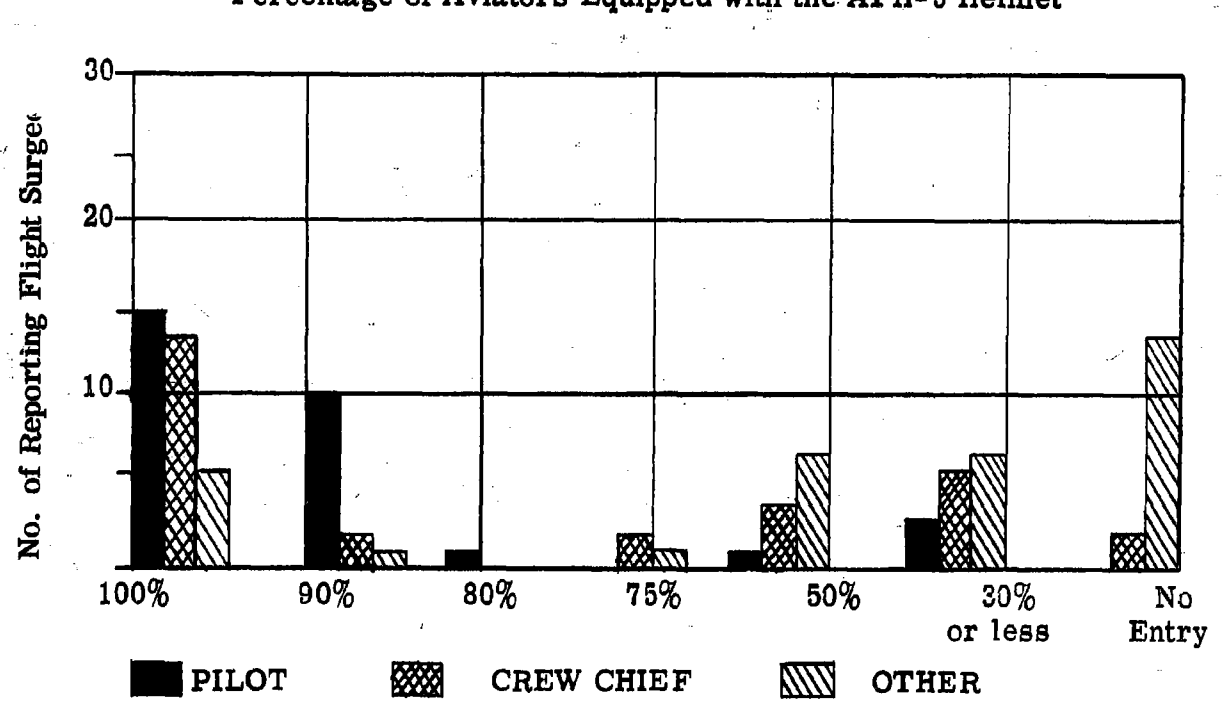
f. Insufficient number of medium sizes.

The difficulty of improper sizes and inadequacy of initial supply persisted throughout the period. During this time aviators were required to fly without protective head gear, rely on borrowing a helmet or using other models procured prior to the APH-5 issue.

"4. What percentage of your aviators are equipped with the APH-5 helmet? of crew chiefs, others. If less than 100% in any of the above categories, why?"

The item tabulation is shown in Table 3. It shows 16 of the flight surgeons were unable to report their aviators were 100% equipped. However, 26 of them reported more than 90% of their aviators were equipped. The crew chiefs did not fare as well. Only 17 of the reporting units had 90% of their crew chiefs equipped. The "other" group which includes flight surgeons, observers and the like, as expected, were most lacking. This table reveals that a helmet shortage still exists.

Table 3
Report of Thirty-One Flight Surgeons



In locations where the pilots were not 100% equipped the flight surgeons offered these reasons. Several were cited more than once.

a. Initial allocation insufficient.

b. Helmets are available but several pilots continue to use the AF model.

c. Availability and other supply difficulties.

d. Two of three units 100% equipped. One unit 50% supplied with helmets on requisition since May 1960.

e. Aviators on PCS take the helmet with them. Those arriving have none.

f. Students here for advanced school on TDY are not furnished helmets, since local unit cannot provide for recurring expense of purchase.

g. Few aviators attached to the aviation unit for flying only (have ground jobs with non-aviation units) do not have helmets.

h. No more available in supply channel.

i. Aviators arriving this overseas station report they were required to turn their helmet in prior to departing the U. S.

j. Aviators assigned directly from flight school do not bring a helmet with them. A requisition usually takes six to eight weeks to be filled.

"5. Have any cases of helmet structure failure occurred at your station? What part failed?"

Fourteen flight surgeons reported failures have occurred at their station. Major failures have occurred in the shell assembly and chin strap. In four of these failures, fatalities resulted. However, in three of these four, the shell assembly was subjected to extreme "G" forces estimated to be beyond its design limits. The chin strap failure resulted in loss of the helmet, allowing the pilot to receive fatal head injuries. In the other case, the shell assembly did not fail. It absorbed all of the forces which crumpled/creased the shell. The pilot did not receive fatal injuries. In addition to these major failures, the sun visor, earphones, and pads have failed.

Table 4

Helmet Structure Failures*

Frequency of Failure	Component	Reporting Flight Surgeon's Remark
7	Shell assembly	Entire shell crushed, extreme "G" forces, three fatalities Crack about ear piece at a point where visor housing mounts on the shell - fatal Three cases of minor transverse cracks, shell crumpled but prevented serious injury
4	Sun visor	Two cases of broken visors difficult to manipulate, visor catch broke
3	Pads	Pads won't stay in - have resorted to a rubber base cement
1	Chin strap	Broke - fatal to pilot
1	Earphones	Malfunction due to sweat

"6. Is there much reluctance among your aviators to wear the helmet? If so, what is their greatest objection? (e.g., heat, weight, fit, etc.)"

Seventeen of the 31 responding flight surgeons reported objections of their aviators to wearing of the helmet. These objections are tabulated in Table 5. The helmet's heat retaining characteristic, its tight fit and weight are objected to most frequently. Reportedly, aviators performing the mission of flying VIP personnel, do not wear the helmet because none are provided or required to be worn by their passengers. Though the basis for the reasoning in this case is evident, it is hardly justified, considering the pilot's exposure versus that of his passengers. His far outdistances that of the passengers. It may be far wiser in the interest of the safety of the passengers for the pilot to wear his helmet. Turbulent air or some similar condition may cause the pilot to receive

*For period ending April 1961

a blow on the head, render him unconscious or in some other way impair his ability to fly the aircraft. In spite of psychological implications, considering the status of the passengers, flying without the helmet is not in the best interest of their safety.

Table 5

Pilots' Objections to Wearing the Helmet

Frequency		
14	Heat retention	- because of this some pilots only wear it during takeoff and landing
8	Tight fitting	- only three sizes available which results in a poor uncomfortable fit. Develops a painful area on the head after prolonged use even with properly fitted helmet.
1	Color	
1	Rough finish	
1	No facility for hood mounting, hence helmets are not worn during instrument check rides	
1	Interferes with hearing	
1	VIP flights	- no helmets provided for passengers which gives a reason for the pilots not to wear them

"7. Have you had any experience modifying the APH-5 helmet to fit an oxygen mask? If so, for what aircraft? Do you anticipate any trouble for such a modification? If yes, explain."

Only two flight surgeons responded affirmatively to the first part of this question. In these cases the L-23 and U-1A were the only aircraft flown. Neither flight surgeon anticipated any trouble with the exception of getting required parts.

Three comments were made by flight surgeons anticipating modification troubles. One stated, "There will in all probability be a multitude of oxygen masks rather than one standard mask." This statement suggests the need for Army aviation to standardize its oxygen mask requirement while the problem is still in its infancy. One flight surgeon assumes trouble will be inevitable since there already has been trouble with masks, e.g., receiving them incomplete from supply. Another flight surgeon anticipated trouble with the mike attachment, difficulty in use of the visor slide, and chin strap fastening.

The purpose of the item was to survey troubles already encountered with the oxygen mask, trying to anticipate the nature of the difficulty when aircraft similar to the AO-1 Mohawk arrive. The cited troubles are real and need to be alleviated in a relatively short time.

> "8. List improvements you think should be made to the helmet to increase overall effectiveness of the helmet program."

Twenty seven of the 31 respondents considered this item. As a group, they submitted 77 recommendations.

Table 6

Recommendations for Improving the Helmet

Recommendations for Improvement	Frequency
Chin Strap	10
Improve release and adjustment device, too hard to get to, especially to tighten properly	4
Modify - either incorporate a cup, a posterior additional attachment or a padded and wider chin strap	3
Modify - incorporate a broader, softer, stronger surface, less likely to fail or cut the chin	1
Modify - adopt Haroman type adapter with the molded chin cup	1
Provide chamois covering for strap and front pad that is easily replaced and cleaned	1

Recommendations for Improvement	Frequency
Sun Visor	**5**
Provide additional shades of tinted visors	1
Remove distortion through curved visor, a distinct hazard	1
Eliminate visor with preference placed on a clear visor and use of sun glasses when needed	1
Eliminate black tape around visor edge	1
Earphones/Cushions	**2**
Issue a sweat absorbing liner over earphones	2
Shell Assembly	**26**
Change to a light highly reflective color	16
Air condition in some manner perhaps with an air jet	6
Change to a smooth outer finish	2
Develop a suspension system to allow greater air circulation about the head	1
Increase the overall strength of the shell	1
Pads	**12**
Replace pad with material more energy absorbent material	6
Improve the quality of the adhesive	3
Modify front pad so sweat does not flow into eyes	2
Employ pads of channel construction type to aid air circulation	1
Miscellaneous	**22**
Make replacement parts available	3
Issue a carrying bag	2
Make wearing the helmet mandatory - a regulation to this effect	2
Individual fitting for each aviator to his head dimensions	2
Decrease weight and bulkiness	2
Develop nape straps that don't stretch out and more adjustments available	2
Have flight surgeon dispense helmet to insure proper fit. Over 20% of the helmets given to aviators are not fitted, i. e., proper size, fittings of pads and nape strap	1
Develop a better system for fitting	1
Make the helmet compatible with the oxygen mask	1
Make the helmet compatible with the protective mask	1
Place more helmets in supply channels	1

Recommendations for Improvement	Frequency
Issue the helmet through the local aviation unit supply	1
Issue helmets for permanent retention to the students while at Fort Rucker where they are more easily and quickly procured than this remote station	1
Issue more of the medium sizes	1
Make communication and configuration changes which will make it necessary to allow for wearing of the helmet	1
No Comment	4

C. DISCUSSION OF ANALYSIS OF AVIATOR RESPONSE

"1. I am _____ rotary wing qualified; _____ fixed wing qualified. During the past year I have logged most of my time in aircraft model _____ and _____.

The purpose of this item was to determine the adequacy of sampling from which this information was gathered. The aviator population used in comparison was as of December 1960.

Table 7

Comparative Aviator Qualifications

Type of Rating/Qualification	Aviator Population At Large	Aviator Population Questionnaire
Fixed Wing	25.6%	13.9%
Rotary Wing	20.6%	21.7%
Combined R/W & R/W	53.8%	64.3%

The aircraft in which the aviators logged most of their time during the past year is given in Table 8. Six aviators failed to indicate the aircraft.

From the comparative qualifications and the kind aircraft flown by these aviators it is reasonable to assume the sampling represent a cross section of the Army aviator population. Keep in mind, however, that this sampling of 133 aviators represents only 2% of the aviator population.

Table 8

Aviator's Aircraft Experience

Model	Frequency	Model	Frequency
H-13	36	L-19	32
H-19	9	L-20	45
H-21	34	L-23	10
H-23	19	U-1A	17
H-34	12	AC-1	1
H-37	7		
HU-1A	5		

"2. Do you have an APH-5 helmet issued on a personal property basis? Is the helmet issued on a temporary basis? Is the helmet issued only for each flight? Are you using a helmet model other than an APH-5? If yes, what model?"

This multiple item sought to determine the number of aviators who were issued an APH-5 helmet as personal property and if not, what is done in lieu of this practice.

Numerically, the responses to the first two parts of the item were identical. That is, 129 aviators stated they were issued the APH-5 helmet as personal property. Only three aviators reported the helmet issued on a temporary basis.

No one reported the helmet issued on a one flight basis. Only one aviator stated using another model, an AF-APH-4, helmet. From item 2, it can be said the APH-5 helmet is in rather wide distribution. There appears to be little or no need for new practices in issuing the helmet to be adopted.

This finding may appear in conflict with the information of the Flight Surgeon's Questionnaire. For of the 31 responding flight surgeons, only 16 of them state 100% of their pilots are equipped with the APH-5 helmet. The apparent reason for this reported difference is that the flight surgeon's findings cover four times the number of stations.

"3. Does the APH-5 helmet go with you on a PCS?"

The purpose of this question was to cross check the findings of item 2. It sought to determine the interpretation made of the item. The response showed that 114 (86%) of the aviators were permitted to take their helmet with them on a PCS move. Though this percentage is somewhat less than the returns of item 2, it does indicate a 15% over supply of helmets at most stations would insure all aviators of having a helmet when needed.

"4. Have you had an experience in which you think wearing the helmet saved you from injury?"

This item found only nine of the aviators to say the helmet saved them from injury. The item did not ask for a description of the "save" nor did any of the aviators offer one. As response to other items indicate, most of the aviators' comments of helmet deficiencies can be classified as comfort and convenience factors. The relatively small number of "saves" found by this item is probably the reason for the tenor of the aviators criticisms, that is, their tendency to emphasize comfort and convenience.

"5. Do you find that the APH-5 helmet

a. Is too heavy and tiring to wear

b. Is too hot

c. Is difficult to get "on" and "off"

d. Interferes with side and rearward vision during flight

e. Other deficiency (explain)"

The above categories were selected because they have appeared as deficiencies in correspondence, in the accident reports and in conversation with aviators and flight surgeons alike. The purpose of the item was to further explore these criticisms.

Table 9

Aviators' Response to Helmet Deficiency

Deficiency	Frequency of Response
Is too heavy and tiring to wear	13
Is too hot	70
Is difficult to get "on and off"	41
Interferes with side and rearward vision	8
Other deficiency (explain)	41

These discrepancies were checked 173 times by the 133 aviators responding, approximating 1.3 checks per aviator. This is to say each aviator had a criticism of the helmet. This is, however, considerably less than the total number of discrepancies that could have been made had each aviator elected to use the maximum number of checks available to him. Accepting this, it may be said these discrepancies are of moderate concern to the aviator. The exception to this tenet is found in the deficiency, "Is too hot." This sub item received 40% of the checks and should be recognized to be of major concern to the aviator. This recognition is borne out in the aviators' response to sub-item E "Other deficiency" and items 8a and 8b.

An unexpected finding of this item was the 41 times the sub-item c "Is difficult to get 'on and off'" was checked. Prior to this study, the discrepancy was not thought to be of this dimension; however, the 41 checks (22%) indicate differently.

Sub-item e "Other" was checked by 41 individual aviators. Though an aviator may have noted more than one "Other," only one check per aviator was tabulated. As the list of deficiencies shows,

these discrepancies are varied, reflecting the aviators' experience with components of the helmet rather than with the helmet as an assembly.

Table 10

Aviators' Response to "Other" Deficiencies

Discrepancy	Frequency of Response
Sun Visor/Eyeshield	9
Difficult to operate in the "up" and "down" positions	3
Hot when down, doesn't fit the nose snugly	1
Scratches too easily	1
Hinders depth perception	1
Replacement visors not available	1
Visor inadequate in reducing effect of haze	1
Blocks visual path to some instruments of the H-21	1
Chin Strap	5
Improve strap fastener	3
Develop chin strap for easy "on" and "off", like the AF model	2
Earphones/Cushions	19
Cushions deteriorate much too rapidly	9
Install netting over cushions to reduce the tendency to perspire	6
Excessive perspiration caused by earphones	2
Earphones too tight, cause pain if worn for extended time	2
Nape Strap	3
Will not stay taut through normal use	3
Shell Assembly	10
Difficult to modify for hooded flight	5
Request change in color	4
Paint chips too easily	1

Discrepancy	Frequency of Response
Miscellaneous	18
Sizing pads will not remain in place	8
Poorly ventilated	2
Replacement parts not available	2
Insufficient head room in many aircraft	2
Inside parts not easily removable for cleaning	1
Mike boom will not adjust to center of mouth	1
*Most comfortable head gear I've worn	1
*Wonderful thing and necessary, however I don't like to wear it	1

"6. Have you modified your helmet in any way which might be of benefit if adopted by aviators? If yes, explain."

Item 6 gave the aviator the opportunity to relate the remedies he found necessary. Eleven aviators modified the helmet. All 11 were rotary wing pilots. Table 11 lists their modifications.

Table 11

Aviators' Modificiations Made to the Helmet

Modifications	10
Installed chamois on chin strap making it less irritating	2
Removed visor and associated hardware. This gives the effect reducing the weight by one-half, eliminating the top heavy feeling	1
Removed oxygen mask snap	1
Installed piece of tape across the bottom of visor guard to prevent scratching visor and to reinforce visor at the bottom of the slot	1
Moved microphone cord to right side to reduce irritation to the back when flying H-23's	1

Modifications

Replaced full pad with strips to allow circulation of ventilating air	1
Used center screw in visor shield for attaching makeshift hood	1
Installed nylon cloth over earphone cushions to reduce perspiration	1
Modified chin strap - testing not yet complete	1
No entry	1

"7. Have you had any experience modifying the APH-5 helmet to fit an oxygen mask? If so, for what aircraft? Do you anticipate any trouble for such a modification? If yes, explain."

Six aviators responded to this item. Three of them modified the helmet for U-1A aircraft, two for the L-23 and one had flown the F9F. Only one reported of any modification difficulty, which was the helmet was not cut wide enough for proper fitting of the mask. In this case, neither the mask type or its model number was reported.

Army aviation's limited experience with oxygen equipment and the requirement for it is evident in the size of response. This small response, less than 5%, may be regarded as a forwarning of the task facing Army aviation. The task with the objectives to educate and sophisticate the aviators in high altitude flight, care and use of oxygen equipment, and what constitutes oxygen discipline in flight.

"8. If you were given the permission and facilities necessary, what change in the helmet would you make to:

a. Make the helmet more comfortable

b. Improve its overall qualities"

This two part item received considerable attention. Part 8a was commented on by 71 aviators making 95 comments. Comment

review shows an overlap existing between parts a and b. This is probably due to the emphasis the aviators place on comfort and convenience factors and since so few of them have had an injury/fatality production experience. In spite of this, identical comments were not reported in both parts of the item.

The tabulation of part 8a "Make the helmet more comfortable" is given in Table 12.

Table 12
Aviator Recommendations to
Make the Helmet More Comfortable

Recommendation		
Chin Strap	13	
Install snap type quick release		4
Remove irritation of snug fitting strap		4
Install cup type chin strap		4
Stronger chin strap		1
Earphones/Cushions/Communication Cord	21	
Install and provide nylon netting for covering of cushions		8
Reduce tension of earphones		6
Develop improved method of holding earphones from ears		2
Replace cushions with a type that can be more easily cleaned and repaired		2
**Helmet fits more comfortably than headset		2
Ventilate cushions		1
Shell Assembly	46	
Reduce head retention qualities		23
Change in color		19
Incorporate ventilating holes		2
Provide a smooth exterior finish		1
Modify to permit easy installation of hood		1

Recommendation		
Miscellaneous	15	
Install oxygen mask fasteners on the outside		2
Improve quality of pad adhesive		2
Make pads of thicker, softer, smoother material		2
Install sweat absorbing band where pad contacts the brow		2
Relocate the microphone cord to the right side		2
Replace pads with complete liner		1
Replace pads with nylon webbing type of suspension		1
Improve the weight distribution from the top of the head		1
**Do not sacrifice safety for comfort		1
*Replace the APH-5 with automotive type helmet which is more comfortable and lighter		1
No Comment	62	

These recommendations, as expected, correlate well with the "Other" deficiencies the aviators stated in item 5. The helmet's heat retention quality again received the greatest response. Twenty three aviators, 24%, made direct statements about the heat while many others alluded to it making such recommendations as change in color, incorporate ventilating holes, install nylon netting over ear cushions, ventilate ear cushions, etc. Heat and its contribution to discomfort certainly should be recognized as a major deficiency and should be given priority consideration in the development of future helmets.

Table 13 gives the tabulation of part b. "Improve its Overall Qualities"

Table 13
Aviators' Recommendations to
Improve the Helmet's Overall Qualities

Recommendation	Frequency
Chin Strap	7
Improve fastener, e.g., install strap so it may be fastened on one side. This will aid in the putting "on" and taking it "off."	6
Install cup type chin strap	1

Recommendation	Frequency	
Sun Visor/Eyeshield	9	
Improve visual characteristics, e.g., distortion, tiring on the eyes, inadequate in haze. Develop a visor with two shades of tint. The darker area near the top for purposes when looking out against the sun. The lighter tint near the bottom so as not hinder depth perception and instrument scanning.		8
Improve facility to move visor "up" and "down"		1
Earphones/Cushions/Communication Cord	6	
Replace cushion material with material that is easier to clean and will not deteriorate as rapidly		5
Slot cushions to fit bows of glasses		1
Shell Assembly	19	
Remove color restriction		11
Bake on finish to reduce tendency to chip		2
Make provisions for attaching instrument flight hood		2
Make side more flexible for easier "on" and "off"		1
Install a small bill to shade direct rays of sun		1
Reduce weight and make less cumbersome		1
Improve ventilating qualities		1
Miscellaneous	18	
Issue helmet carrying bag		6
Improve pad adhesive qualities		6
Improve oxygen mask hookup		2
Accelerate helmet procurement and distribution program		1
Provide cinch type adjustment for the nape strap		1
Install sweat collector on frontal piece		1
Make fitting pads of fire resistant material		1
No Comment	87	

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